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Fundamental Supply Side Determinants of the Real Exchange Rate and the Current Account - an Intertemporal General Equilibrium Approach

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Working Paper No. 7

**Fundamental Supply Side Determinants of the Real
Exchange Rate and the Current Account
- an Intertemporal General Equilibrium Approach –**

by

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and

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1997

Fundamental Supply Side Determinants of the Real Exchange Rate and the Current Account - an Intertemporal General Equilibrium Approach -

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1. Introduction

In the short run monetary shocks have an impact on real variables because, in the goods and factor markets, short run prices are sticky. Therefore, in an open economy with flexible exchange rates, a monetary expansion leads, in the short run, not only to a nominal, but also to a real depreciation of the home currency. However, in the long run, when goods and factor prices are completely flexible, money is neutral; it has no impact on real variables. In the long run the real exchange rate and the current account are determined by real variables. The purpose of this paper is to investigate, in an intertemporal general equilibrium approach, the impact of economically important current and expected exogenous shocks on the real exchange rate and on the current account.¹ Particular emphasis is placed on the impact of supply side shocks on the real exchange rate and the current account via investment. One important new supply side aspect is the explicit consideration of investment installation costs. Although these costs play an important role in the real world, there has been very little consideration of them in economic models dealing with the relation between the real exchange rate and the current account.² It will be shown that, when installation costs are taken into account, the impact of supply side shocks on the expected real exchange rate, and especially on the expected current account, becomes less clear.

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¹ The role of various demand side specifications for the determination of the real exchange rate and the current account have been studied intensively. See for instance Ostry (1988).

² In a lot of empirical papers the importance of internal adjustment costs are investigated. These costs are very like investment installation costs. In the case of replacement investment especially, the internal adjustment costs can - in a cautious manner - be interpreted as a lower bound for the installation costs. Lichtenberg (1988) estimates adjustment costs as 21 % of the value of the replacement investment.

The paper is organized as follows: in part II the model is developed. Particular emphasis is put on modelling the supply side. In part III the impact of various real shocks on the real exchange rate and the current account are investigated. Part IV summarizes the results and discusses some implications for the future international monetary system.

II. The model³

1. Basic assumptions

Concerning production, there are two sectors in the economy - a sector in which nontradable goods, N, and a sector in which tradable goods, T, are produced. Nontradables, like services, cannot be invested. They are only consumed domestically. Tradables like automobiles can be consumed as well as invested at home. Because they are tradables they can be exported as well as imported. There is also a third good, M, which can only be imported and consumed. If the nominal prices of the three goods are: $\tilde{p}_{N_t}, p_{T_t}, \tilde{p}_{M_t}$ then the relative or real prices of the nontradables and the imported goods – expressed in tradables – are:

$$p_{N_t} = \tilde{p}_{N_t} / \tilde{p}_{T_t} \text{ and } p_{M_t} = \tilde{p}_{M_t} / \tilde{p}_{T_t}.$$

The domestic consumer price level is:

$$(1) \tilde{P}_{C_t} = \alpha_p \cdot \tilde{p}_{N_t}^{\alpha} \cdot \tilde{p}_{M_t}^{\nu} \cdot \tilde{p}_{T_t}^{1-\alpha-\nu} = \alpha_p \cdot p_{N_t}^{\alpha} \cdot p_{M_t}^{\nu} \cdot \tilde{p}_{T_t}.$$

with α and ν representing the share of the nontradables and the imported goods in the consumer goods basket and α_p a constant. The real price of the domestic consumer goods basket, expressed in tradables, then is:

$$(2) P_{C_t} = \frac{\tilde{P}_{C_t}}{\tilde{p}_{T_t}} = \alpha_p \cdot p_{N_t}^{\alpha} \cdot p_{M_t}^{\nu}$$

For the foreign country, there are the same basic assumptions:

$$(1a) \tilde{P}_{C_t}^f = \alpha_p^f \cdot \tilde{p}_{N_t}^{f \alpha^f} \cdot \tilde{p}_{M_t}^{f \nu^f} \cdot \tilde{p}_{T_t}^{f(1-\alpha^f-\nu^f)} = \alpha_p^f \cdot p_{N_t}^{f \alpha^f} \cdot p_{M_t}^{f \nu^f} \cdot \tilde{p}_{T_t}^f$$

$$(2a) P_{C_t}^f = \frac{\tilde{P}_{C_t}^f}{\tilde{p}_{T_t}^f} = \alpha_p^f \cdot p_{N_t}^{f \alpha^f} \cdot p_{M_t}^{f \nu^f}$$

where “f” refers to foreign variables. The tradables are traded between the two countries, whereas the M-good is imported from the foreign country. A very popular and useful definition of the real exchange rate, R_t , is:

³ A standard book for intertemporal models of open economies is Frenkel and Razin (1992). A topical overview of the intertemporal approach to the current account is given in Obstfeld and Rogoff (1995).

$$(3) \quad R_t \equiv S_t \cdot \frac{\tilde{P}_{C_t}^f}{P_{C_t}}$$

where S_t is the nominal exchange rate, i.e. the price of one unit foreign currency, expressed in home currency. R_t then is - analogous to S_t - the price of one foreign consumer goods basket expressed in domestic consumer goods baskets. With a given nominal exchange rate and a given foreign consumer goods price level, an increase in the domestic consumer goods price level leads to a decrease in the real exchange rate, R , i.e., to a real appreciation of the home currency.

Considering (1) and (2) as well as (1a) and (2a) in (3) gives:

$$(3a) \quad R_t = \frac{S_t \cdot \tilde{P}_{T_t}^f \cdot P_{N_t}^{\alpha^f} \cdot P_{M_t}^{\nu^f}}{\tilde{P}_{T_t} \cdot P_{N_t}^{\alpha} \cdot P_{M_t}^{\nu}} \cdot \frac{\alpha_P^f}{\alpha_P} \equiv \frac{S_t \cdot \tilde{P}_{T_t}^f}{\tilde{P}_{T_t}} \cdot \frac{P_{C_t}^f}{P_{C_t}}$$

(3a) shows that the real exchange rate is the product of two components. The first component, $S_t \cdot \tilde{P}_{T_t}^f / \tilde{P}_{T_t}$, usually has a huge impact on R^* when the nominal exchange rate, S_t is very volatile, because of the short run price stickiness in the tradable sector of the two economies. In the long run the “law of one price” between the tradable sectors of the two countries should hold due to international goods arbitrage. That means in the long run that the first component on the right hand side of (3a) becomes one and the real exchange rate is entirely determined by the second component⁴. As we are interested in fundamental long run determinants of the real exchange rate we will make the - bold - assumption that the law of one price in the tradable sector holds. Then (3a) becomes:

$$(3b) \quad R_t = \frac{P_{C_t}^f}{P_{C_t}}$$

The international real interest rate, r_T , that is, the real interest rate at which firms and households can borrow and lend the tradable good internationally, has to be defined in tradables, of course, i.e.:

$$(4) \quad (1 + r_T)$$

with the dimension “units of good T_{t+1} , per unit of good T_t ”. However, when making intertemporal consumption decisions, rational consumers have to consider also the real change in the value of their consumer goods basket due to price level changes. Therefore, the consumer real interest rate, r_C , which is an - important determinant of consumer’s savings, is

$$(5) \quad (1 + r_C) = (1 + r_T) \cdot \frac{P_{C_t}}{P_{C_{t+1}}}$$

⁴ See Marston (1987) for various definitions of real exchange rates and price indices.

At given world real interest rate, an increase in the consumer price level from period t to period $t+1$ implies a proportionate decrease in the consumer real interest rate. This relation between the two real interest rates also holds for the foreign country:

$$(6) \quad (1 + r_C^f) = (1 + r_T) \cdot \frac{P_{C_t}^f}{P_{C_{t+1}}^f}$$

From (5) and (6) follows:

$$(7) \quad (1 + r_T) = (1 + r_C) \cdot \frac{P_{C_{t+1}}}{P_{C_t}} = (1 + r_C^f) \cdot \frac{P_{C_{t+1}}^f}{P_{C_t}^f}$$

and considering (3b)

$$(8) \quad (1 + r_C) = (1 + r_C^f) \cdot \frac{R_{t+1}}{R_t} \equiv (1 + r_C^f) \cdot (1 + \hat{R})$$

where $\hat{R} = \frac{R_{t+1} - R_t}{R_t}$. For reasonably high real interest rates one gets from (8) the familiar international real interest rate parity:

$$(9) \quad r_C - r_C^f \approx \hat{R}$$

(9) indicates that the difference between the consumer real interest rate at home and abroad is equal to the change in the real exchange rate over time. Such an international real interest rate differential, which is caused by the existence of nontradables, can neither be exploited nor eliminated by international goods arbitrage.

2. Supply side⁵

In the following small country case, it is assumed that the international real interest rate, r_T , as well as the prices of tradables, p_T , and imports, p_M , are exogenously given. In modelling the supply and demand side we take the exportables as numeraire and assume - for convenience - that $p_{T_t} = 1$. The time horizon consists of two periods and factors of production are labor, L_t , and capital, K_t . Total labor supply, L_t , is given exogenously in both periods⁶. Labor is internationally immobile. Within the country labor is perfectly mobile, both intra- and intersectorally. Due to complete labor mobility, the wage rate is the same in both sectors in every period. Capital is mobile internationally. On the national level we assume the following: in the first period the capital stock, K_1 , is historically given. Further, in this period also the distribution of the capital stock over the tradable sector, K_{T_1} , and the nontradable sector, K_{N_1} ,

⁵ The basic structure of this model is developed in Razin (1984).

⁶ Asean and Mendoza (1994) present a model with endogenous labor supply.

is historically determined and cannot be changed in this period. However, due to investment in the first period, both the sectoral capital stocks and total capital are flexible in the second period. For simplification, we assume complete depreciation of the capital stock during one period in both sectors. These assumptions imply the following relation between the capital stock of the second period and the investments in period one:

$$(10) K_2 = I_1$$

In each period we have

$$(11) L_t = L_{N_t} + L_{T_t}$$

and

$$(12) K_t = K_{N_t} + K_{T_t}$$

It is further assumed that the firm needs ϕ_1 , units of nontradable goods to install one unit of the investment good. These costs are labeled installation cost. Then the total costs for one additional unit of capital - expressed in units of tradables - are:

$$(13) (1 + \phi_1 \cdot p_{N_1})$$

(13) shows that the technology for building up the capital stock is a Leontief-type in each sector.⁷ Notice that the capital stock increases only by the amount of the investment good, i. e. the amount of the traded good.

Nontradables and tradables are produced with the following technologies:

$$(14) Y_{N_t} = A_{N_t} \cdot \left(L_{N_t}^\gamma \cdot K_{N_t}^{1-\gamma} \right)$$

$$(15) Y_{T_t} = A_{T_t} \cdot \left(L_{T_t}^\beta \cdot K_{T_t}^{1-\beta} \right)$$

where Y_{j_t} , is the production of the good j in period t and a change in A_{j_t} represents technical progress. Total domestic production in each sector and each period can be distributed as national income. Assuming a zero net foreign position initially, then the wealth of the economy, W , expressed in tradables, is defined as the present value of total national income of the two periods:

⁷ See Brock (1988) for a similar formulation. The assumption of complete capital depreciation is here very helpful. If there is any capital stock left at the end of period one, we need a more general formulation of the installation costs:

$$(1+i \cdot \phi_1 \cdot p_{N_1}) \text{ with } i = \begin{cases} 1 & \text{for } I_1 > 0 \\ -1 & \text{for } I_1 < 0 \end{cases}$$

$$(16) \quad W = p_{N_1} \cdot Y_{N_1} + Y_{T_1} + \frac{1}{1+r_T} \cdot (p_{N_2} \cdot Y_{N_2} + Y_{T_2}).$$

We assume that firms minimize their costs. Because of the historical given stock of capital, this is a very simple problem in the first period: Each firm hires the required amount of labor to produce a specific output level. With a wage rate that is equal to the value of the marginal product of labor in both sectors, equations (18) and (19) follow. For the second period firms calculate with labor costs w^{\wedge} and capital costs

$$(17) \quad (1 + p_{N_1} \cdot \varphi_1) \cdot (1 + r_T).$$

Notice that the capital goods must be bought one period before the firm can use them in the production process. Cost minimization together with the zero-profit conditions for the long run leads to conditions (20) and (22) in the sector of the tradable good and to conditions (21) and (23) in the sector of the nontradable good.

$$(18) \quad A_{T_1} \cdot \beta \cdot k_{T_1}^{1-\beta} = w_1$$

$$(19) \quad A_{N_1} \cdot p_{N_1} \cdot \gamma \cdot k_{N_1}^{1-\gamma} = w_1$$

$$(20) \quad A_{T_2} \cdot \beta \cdot k_{T_2}^{1-\beta} = w_2$$

$$(21) \quad A_{N_2} \cdot p_{N_2} \cdot \gamma \cdot k_{N_2}^{1-\gamma} = w_2$$

$$(22) \quad A_{T_2} \cdot (1-\beta) \cdot k_{T_2}^{-\beta} = (1+r_T) \cdot (1 + \varphi_1 \cdot p_{N_1})$$

$$(23) \quad A_{N_2} \cdot p_{N_2} \cdot (1-\gamma) \cdot k_{N_2}^{-\gamma} = (1+r_T) \cdot (1 + \varphi_1 \cdot p_{N_1})$$

where k_{j_t} is the capital intensity in the j -sector in period t . (18) to (23) contain all necessary information about the supply side. In period two, both the price of nontradeables, p_{N_2} , and the relation between the optimal capital intensities in the two sectors, k_{N_2} and k_{T_2} , are entirely determined by the supply side of the economy. The demand side has no direct impact on the price of nontradables in period two or on the relation between the two factor intensities. From (20) to (23) follows:

$$(24) \quad p_{N_2} = \frac{A_{T_2}^{\gamma/\beta}}{A_{N_2}} \cdot \Omega \cdot \left[(1+r_T) \cdot (1 + \varphi_1 \cdot p_{N_1}) \right]^{\beta-\gamma/\beta}$$

$$= \phi_2(r_T, p_{N_1}, \dots)$$

$$\text{with } \Omega = \left(\frac{\beta}{\gamma} \cdot [1-\beta]^{(1-\beta)/\beta} \right)^{\gamma} \cdot \left(\frac{1}{1-\gamma} \right)^{(1-\gamma)} > 0$$

and

$$(25) \quad k_{T_2} = \frac{\gamma}{\beta} \cdot \frac{1-\beta}{1-\gamma} \cdot k_{N_2}$$

(24) shows the supply side factors which determine p_{N_2} , conditional on the price of the nontradables in period one. The impact of a change in the international real interest rate on p_{N_2} obviously depends on the relation between β and γ . It will be assumed here and in the following that the nontradable sector is the labor intensive one, i.e. $\gamma > \beta$. With this - by no means unrealistic - assumption an increase in the international real interest rate leads - via the supply side - to a decrease in the price of nontradables in the second period. The economic interpretation of this is the following: when the interest rate increases capital becomes more expensive relative to labor. Therefore companies have an incentive to produce more labor intensively. With constant supply of capital and labor in the economy, a more labor intensive production can only be achieved by reducing the production of the labor intensive good, N_2 , and increasing the production of the capital intensive good, T_2 . This shift in production towards the tradables goes along with a lower relative price of nontradables. In Figure 1 an increase in the international real interest rate leads to a shift of the production point on the transformation curve from left to right, such as from point A to point B. At point B the price of N_2 , expressed in T_2 , - measured by the inverse slope of the transformation curve at point B - is lower than at point A.

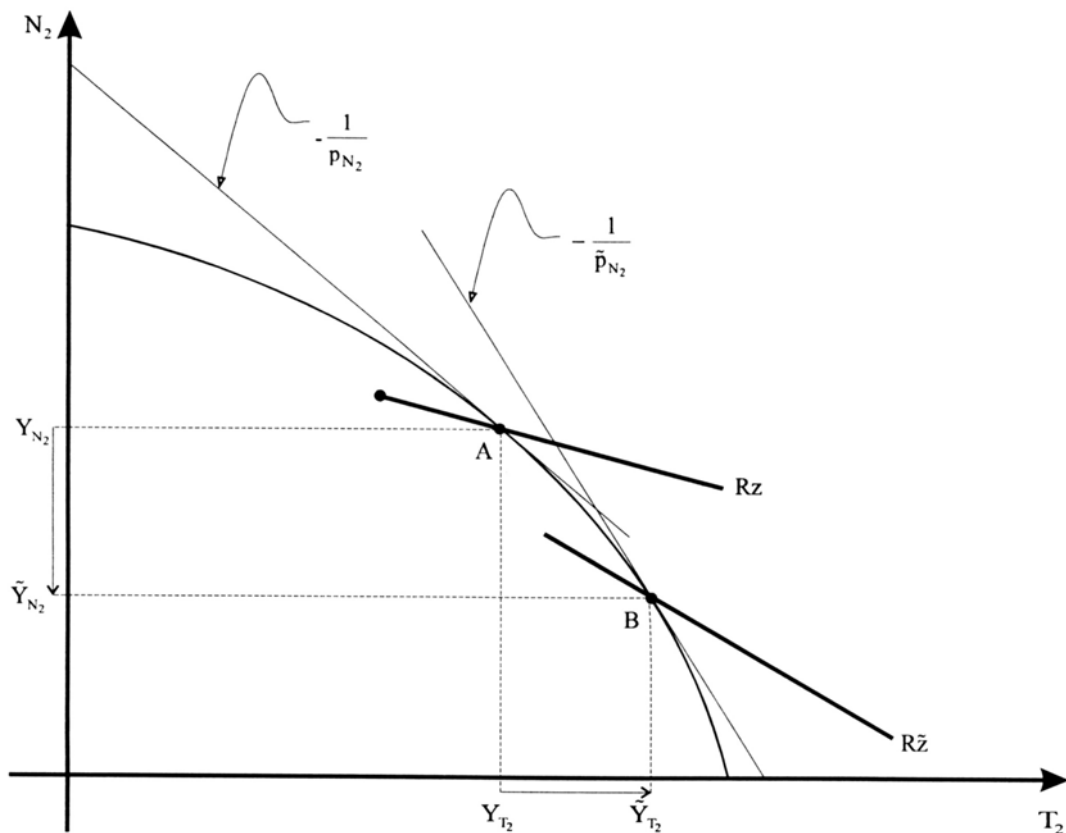


Figure 1

An increase in p_{N_1} will also reduce the price of the nontradables in period two. The argument here is similar: an increasing nontradables price in period one leads to higher installation costs and reduces, *ceteris paribus*, the optimal capital intensities in both sectors. With the fixed supply of labor, at any given investment level there must be an increasing share of tradables and a decreasing one of nontradables, so that the national capital intensity is compatible with the total capital and the total labor amount. This implies that the economy chooses a point on the transformation curve which is more in the south east.

Before turning to the demand side it is necessary to understand the impact of investment on the supply side. Investment in period one leads to an increase in the capital stock in period two and this implies more production possibilities in that period. Graphically, the transformation curve in the second period shifts away from the origin. With given factor and product prices, the additional capital can only be employed when the production of the capital intensive product, T_2 , is increased and that of the labor intensive product, N_2 , decreased. If the original production point in figure 2 were point A, then the new point on the new transformation curve - which is due to investment in period one - has to be south east of point A such as at point B. Connecting these two points gives the line Rz, which will be called “Rybczynski line”. This Rybczynski line is the geometric location of all production

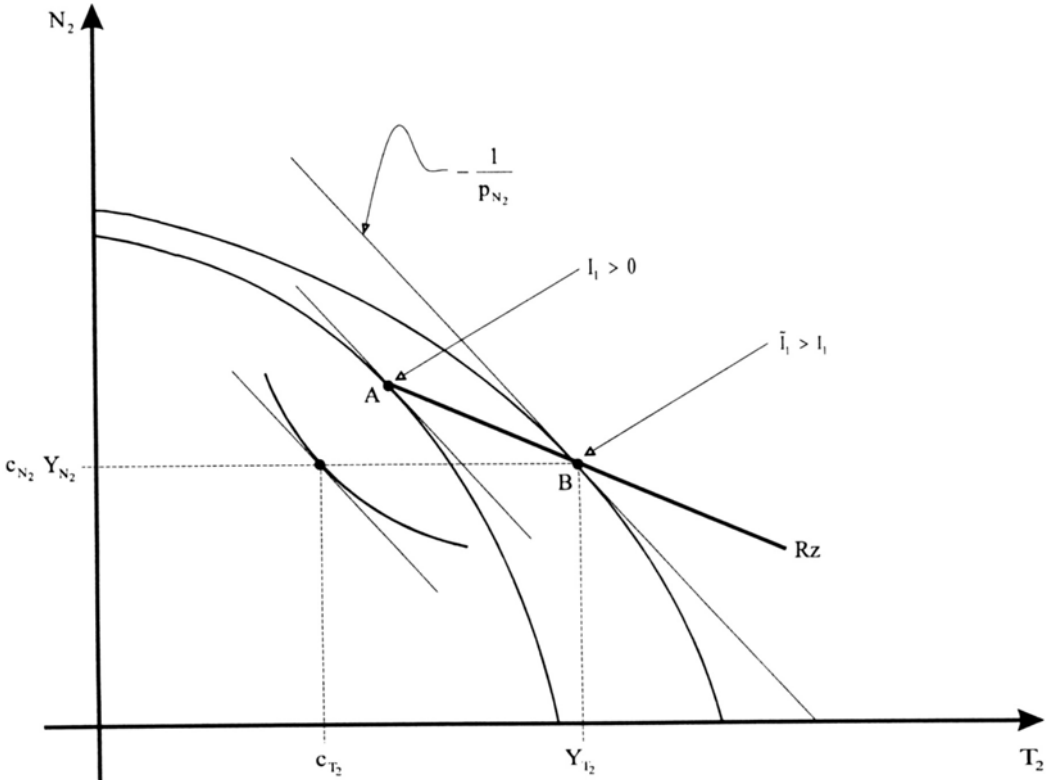


Figure 2

combinations of N_2 and T_2 with alternative investment volumes in period one. The actual amount of investments depends on how much of the nontradables will be demanded in period two. Whenever the demand for the nontradables in period two increases (decreases), companies will decrease (increase) investment in period one to adjust the capital stock of period two so that the supply of the nontradables in period two can adjust optimally to the change in demand. Investment is completely demand side driven. We come back to this in general equilibrium.

The slope of the Rz curve can be calculated:

$$(26) \left. \frac{dY_{N_2}}{dY_{T_2}} \right|_{Rz, dI_1} = - \frac{A_{N_2}}{A_{X_2}} \cdot \frac{k_{N_2}^{1-\gamma}}{k_{T_2}^{1-\beta}} = - \frac{\beta}{\gamma} \frac{1}{p_{N_2}}$$

(26) shows that the slope of the Rybczynski line is - absolutely - smaller than that of the price line. With an additional investment unit, we get an increase in national income in the tradable sector by

$$(27) dY_{T_2} \Big|_{dI_1} = \frac{\gamma}{\gamma - \beta} \cdot (1 + r_T) \cdot (1 + \phi_1 \cdot p_{N_1})$$

and a decrease in national income in the nontradable sector by

$$(28) dY_{N_2} \Big|_{dI_1} = - \frac{1}{p_{N_2}} \cdot \frac{\beta}{\gamma - \beta} \cdot (1 + r_T) \cdot (1 + \phi_1 \cdot p_{N_1})$$

From (27) and (28) we can calculate the increase in national income due to the investment increase:

$$(29) \frac{\partial Y_2}{\partial I_1} = (1 + r_T) \cdot (1 + p_{N_1} \cdot \phi_1)$$

(29) indicates that the investment at home has the same yield as the investment in the international capital market. If the firm invests in physical capital at home she needs not only the interest and repayment of the capital unit but also the repayment of the installation costs. Due to optimal investment decision along the Rz line, the national income of period two - measured in tradables of that period - increases according to (29) for every new capital unit installed.

3. Demand side

The representative household is assumed to have the following utility function, which implies an intertemporal elasticity of substitution of one:

$$(30) U = \ln \left(c_{N_1}^\alpha \cdot c_{M_1}^\nu \cdot c_{T_1}^{1-\alpha-\nu} \right) + \delta \cdot \ln \left(c_{N_2}^\alpha \cdot c_{M_2}^\nu \cdot c_{T_2}^{1-\alpha-\nu} \right)$$

where $\delta \equiv \frac{1}{1+z}$ and z is the marginal time preference of the representative household, c_{jt} measures the amount of good j consumed by the representative household in period t . Now let us define the number of consumer goods baskets, C_t , which are consumed in period t , as:

$$(31) C_t = c_{N_t}^\alpha \cdot c_{M_t}^\nu \cdot c_{T_t}^{1-\alpha-\nu}$$

and then the utility function (30) can be written

$$(32) U = \ln C_1 + \delta \cdot \ln C_2.$$

The time separability of this particular specification of the utility function allows a two-stage budgeting.⁸ First the household can allocate its wealth, which is the present value of its total income, to the consumption expenditure in the two periods. In a second step, it can determine the structure of its consumer goods baskets within each period. This determination of the composition of the consumer goods baskets in the two periods is independent of the intertemporal allocation of the consumption expenditures. The budget constraint over the two periods is:

$$(33) P_{C_1} \cdot C_1 + \frac{1}{1+r_T} \cdot P_{C_2} \cdot C_2 = W$$

Maximizing (32) under the constraint of (33), from the first order conditions we get the marginal rate of intertemporal substitution:

$$(34) \text{MRiS}_{C_2;C_1} \equiv -\frac{dC_2}{dC_1} = \frac{1}{\delta} \cdot \frac{C_2}{C_1} = (1+r_T) \cdot \frac{P_{C_1}}{P_{C_2}}$$

From (34) and (33) we get the demand function for the two consumer goods baskets, which are net substitutes:⁹

$$(35) C_1^d = \frac{1}{P_{C_1}} \cdot W \cdot \frac{1}{1+\delta}$$

and

$$(36) C_2^d = \frac{1+r_T}{P_{C_2}} \cdot W \cdot \frac{\delta}{1+\delta}$$

The special construction of the consumer goods baskets implies that the expenditure on one good is equal to the expenditure in that period multiplied with the exponent of the

⁸ See Deaton and Muellbauer (1980), pp. 120.

⁹ The term 'net substitutes' is used in the sense of a positive Hicks-Alien substitution effect. For details see Chung (1994), pp.11.

consumption good. For the three goods, we get the following demand functions for each period:

$$(37) \quad c_{N_1}^d = \alpha \cdot \frac{1}{p_{N_1}} \cdot W \cdot \frac{1}{1 + \delta}$$

$$(38) \quad c_{M_1}^d = \upsilon \cdot \frac{1}{p_{M_1}} \cdot W \cdot \frac{1}{1 + \delta}$$

$$(39) \quad c_{T_1}^d = (1 - \alpha - \upsilon) \cdot W \cdot \frac{1}{1 + \delta}$$

$$(40) \quad c_{N_2}^d = \alpha \cdot \frac{1 + r_T}{p_{N_2}} \cdot W \cdot \frac{1}{1 + \delta}$$

$$(41) \quad c_{M_2}^d = \upsilon \cdot \frac{1 + r_T}{p_{M_2}} \cdot W \cdot \frac{1}{1 + \delta}$$

$$(42) \quad c_{T_2}^d = (1 - \alpha - \upsilon) \cdot (1 + r_T) \cdot W \cdot \frac{1}{1 + \delta}$$

The specific utility function implies that the cross price elasticities are zero. The demand for each good depends only on the price of that particular good and on wealth. When the price of another good changes, the income and the substitution effect in the Slutsky equation cancel out. This simplification of the demand side makes it much easier to investigate the supply side impact on the real exchange rate and the current account.

4. The equilibrium

There are three goods and two periods, i.e. there are six goods markets. Applying Walras' law, it is sufficient to consider five markets. For convenience we will neglect the market for tradables in period one, because we used the T-good as numeraire. For the other five markets there are the following equilibrium conditions:

$$(43) \quad c_{N_1}^d = \varphi_1 \cdot I_1 = Y_{N_1}$$

$$(44) \quad c_{M_1}^d = m_1$$

$$(45) \quad c_{M_2}^d = m_2$$

$$(46) \quad c_{X_2}^d = Y_{T_2} - x_2$$

$$(47) \quad c_{N_2}^d = Y_{N_2}$$

m_t is the quantity imported of the good M^{\wedge} and x^{\wedge} is the quantity exported of the good T_t . It is possible for x_t to become negative in one period, but this is not possible for m_t . From the intertemporal international budget constraint we get for x_2 :

$$(48) \quad x_2 = p_{M_2} \cdot m_2 + (1 + r_T) \cdot (p_{M_1} \cdot m_1 - x_1)$$

Figures 3a and 3b show the general equilibrium in the case of a current account deficit in the first period, CAD_1 , which, of course, must be equal to the discounted current account surplus in the second period, $CAS_2/(1 + r_T)$.¹⁰

¹⁰ The graphical representation diverges from the general assumption of a balanced current account in the initial equilibrium.

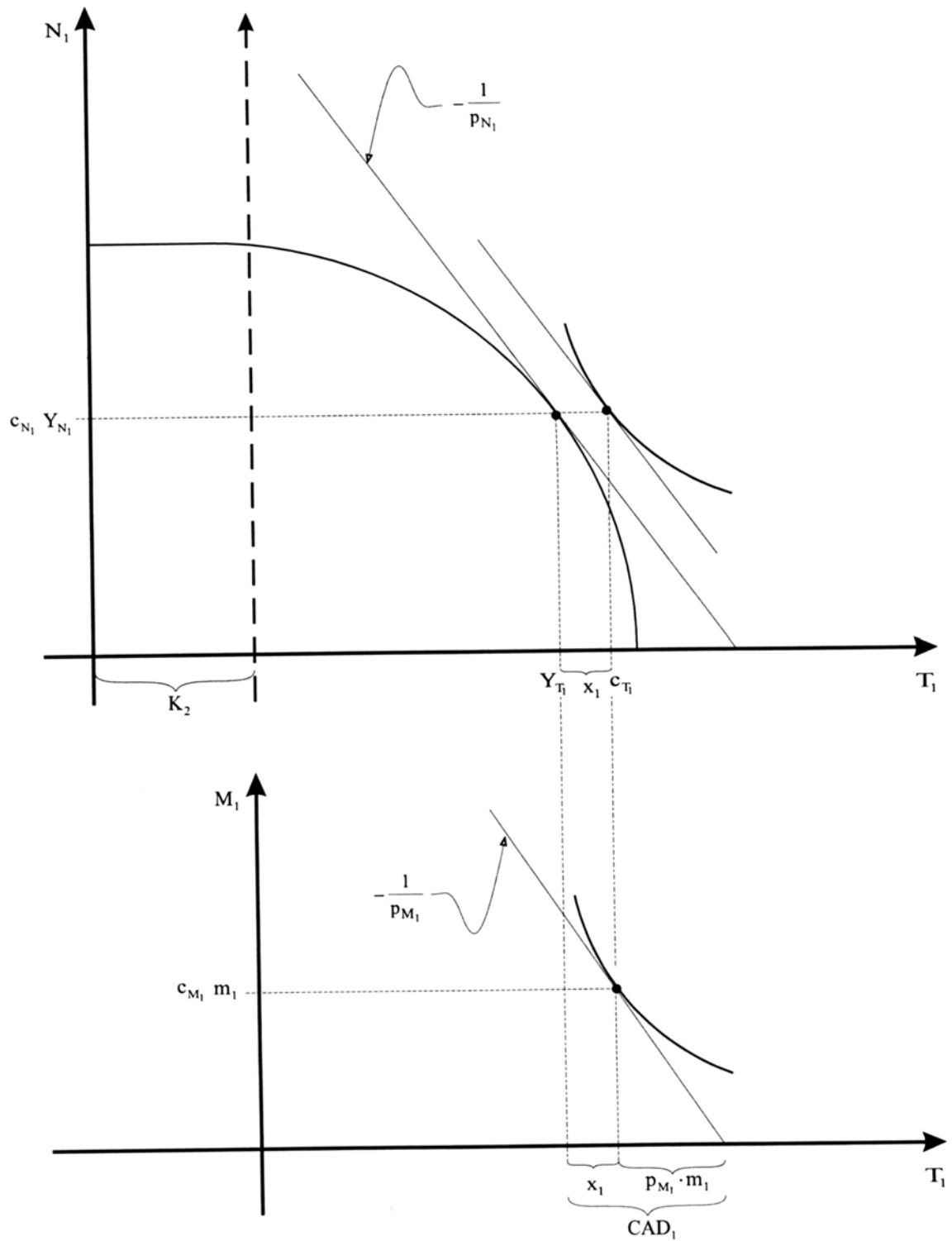


Figure 3a

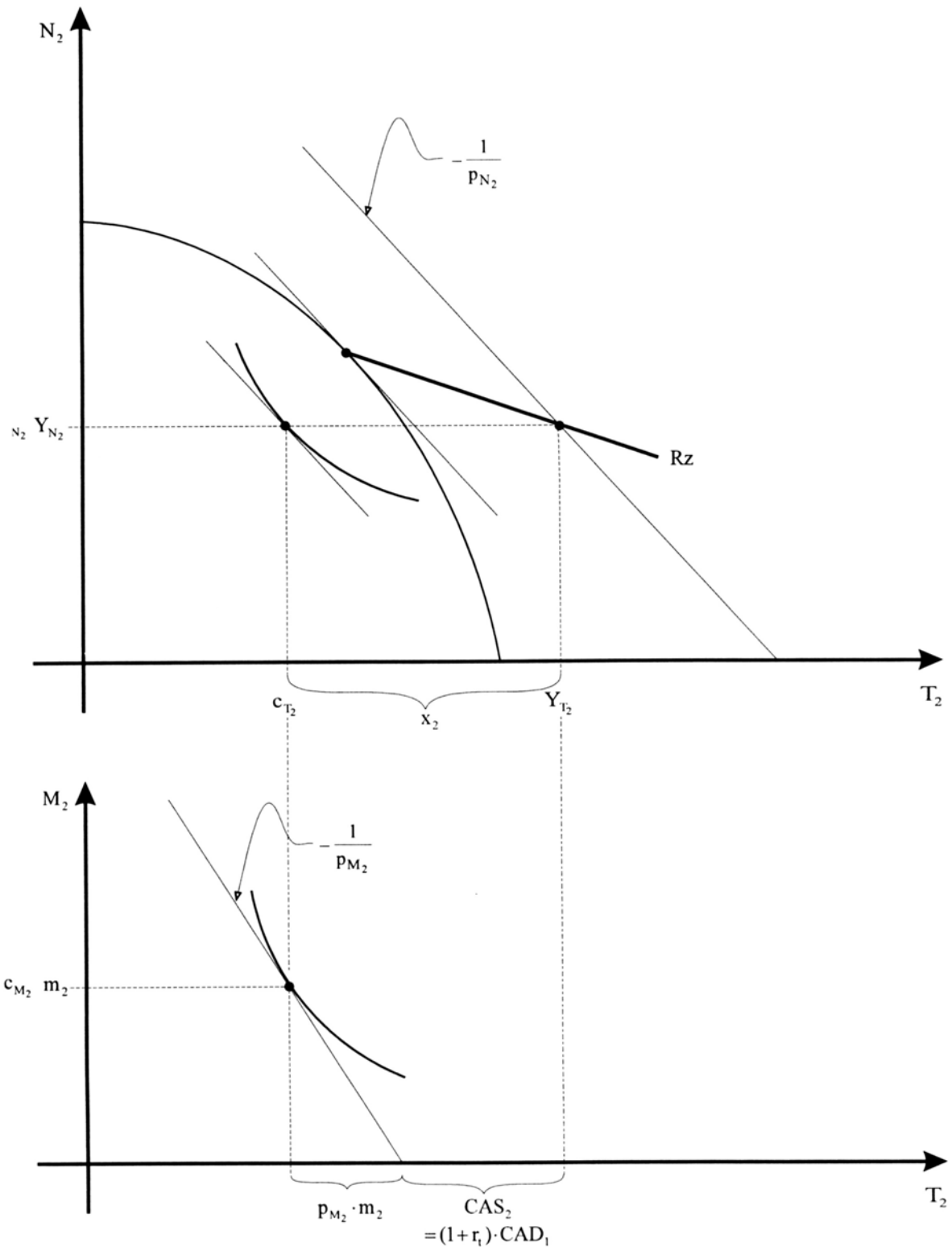


Figure 3b

Totally differentiating (43) to (47) with (48) and (24) the following system can be written:

$$(49) \mathbf{A} \cdot \bar{\mathbf{u}} = \mathbf{B} \cdot \bar{\mathbf{v}}$$

with

$$(50) \mathbf{A} \equiv \begin{bmatrix} a_g & h \end{bmatrix}_{(5 \times 5)}$$

$$(51) \mathbf{B} \equiv \begin{bmatrix} b_g & h \end{bmatrix}_{(5 \times 9)}$$

$$(52) \bar{\mathbf{u}}' \equiv (\mathbf{u}_g)' = (dp_{N_1}, dm_1, dm_2, dx_1, dK_2)$$

$$(53) \bar{\mathbf{v}}' \equiv (\mathbf{v}_g)' = (dL_1, dL_2, dr_T, dp_{M_1}, dp_{M_2}, dA_{N_1}, dA_{T_1}, dA_{N_2}, dA_{T_2})$$

As shown in the appendix, the determinant of the matrix \mathbf{A} , $|\mathbf{A}|$, is positive, \mathbf{u} and \mathbf{v} are column vectors representing the changes of endogenous and exogenous variables respectively. g and h are indices for rows and columns of the matrixes. In matrix \mathbf{A} , we have the coefficients of the excess demand and, in matrix \mathbf{B} , those of the excess supply. They are arranged in rows for the markets N_1 , M_1 , M_2 , T_2 , and N_2 . The two matrices are shown in the appendix. In order to concentrate on these supply side effects, it is useful to work with the very simple utility function (30), which implies cross price elasticities of zero.¹¹ Therefore wealth effects, i.e. supply side induced changes of the present value of income, play an important role.

So a closer look at the elements of the matrix seems to be appropriate: for example, the element

$$(54) a_{1 \ 1} \equiv \frac{\partial c_{N_1}}{\partial p_{N_1}} - \frac{\partial Y_{N_1}}{\partial p_{N_1}}$$

represents the excess demand for nontradables in period 1 due to a change in the relative price. The change in p_{N_1} , has - via installation costs - an impact on p_{N_2} , which changes wealth and the demand for N_1 , in a second way. Therefore, the element $a_{1 \ 1}$, represents the total impact of a change in p_{N_1} on the excess demand, including the p_{N_2} effect. The same holds for the other elements in the first column of matrix \mathbf{A} and in the columns of matrix \mathbf{B} representing the exogenous variables r_T , A_{N_2} and A_{T_2} .

The change in the real exchange rate in period t , caused by exogenous supply side shocks, can be calculated from (3b) together with the appropriate solutions of the system (49):

$$(55) dR_t = \sum_{\substack{g=1 \\ g \neq 4,5}}^9 \left[-\alpha \cdot \frac{R_t}{p_{N_t}} \cdot \frac{dp_{N_t}}{dv_g} \right] \cdot dv_g$$

¹¹ For a closer look at the demand side see Ostry (1988).

where $\frac{dp_{N_t}}{dv_g}$ represents the multiplier of the change in the equilibrium price of the nontradables in period t.

In (55) it is assumed that the price index of the foreign goods basket does not change. Thus in the case of a change in the price of the import good M $dp_{M_t} = dp_{M_t}^f$ it is necessary to have a compensating change in the price of the foreign nontradables. This will be possible if we think about a shift in demand away from the N-good and towards the M-good in the foreign country, which leaves the price of the T-good and the foreign price index unchanged. Contrary to (55) we now have also - as seen from (3a) and (2) - an additional direct effect on the real exchange rate. This leads to the following expression:

$$(56) \quad dR_t = R_t \cdot \left[-\frac{v}{p_{M_t}} - \frac{\alpha}{p_{N_t}} \cdot \frac{dp_{N_t}}{dp_{M_t}} \right] \cdot dp_{M_t}$$

In (56) the direct effect of a change in the terms of trade is indicated by the first term in square brackets which is omitted in equation (55).

III. The impact of supply side shocks on the real exchange rate and the current account

Before the impact of a change in the exogenous variables on the real exchange rate and the current account is investigated, it is useful to explain the various transmission mechanisms. First, current and expected supply side shocks change total wealth in the economy. This change in wealth alters consumers' demand for the three goods in the two periods. Secondly, as p_{M_t} and p_{T_t} - are determined on the world market, and p_{N_2} is determined by the world interest rate and the supply side - conditional on p_{N_1} -, consumers' demand has only a direct impact on the price of nontradables and thus on the real exchange rate in the first period. However, consumers have an indirect impact on the real exchange rate in the second period through their impact on the price of nontradables in period one via the installation costs. Third, in both the market for imports and the market for tradables the change in consumers' demand is transmitted directly to the current account. Fourth, the change in consumers' demand on the market for nontradables of the second period determines the amount of investment in the first period. Companies invest the amount that, at the given world interest rate and the given price for nontradables in period two, ensures that the production capacity in the nontradable sector satisfies consumers' demand. Fifth, investment has an impact on the current account in both periods. Increasing (decreasing) investments deteriorate (improve) the current account in the first period and improve (deteriorate) the current account in the second period.

1. Increase in total factor productivity in the tradable sector in period one:

$$dA_{T_1} > 0^{12}$$

There has been a great deal of discussion of this case in theory, because of its practical relevance. Conventional wisdom is that this kind of supply shock leads to a decrease in the real exchange rate - Belassa-Samuelson-theorem - and to an improvement in the current account. In our intertemporal general equilibrium approach, some of these results are also obtained and some are modified considerably. The supply side effect of the increase in A_{T_1} , is - at constant product prices - the following: first, due to the A_{T_1} increase, production in the tradable sector increases. Secondly, as capital is immobile between the two sectors in period one, labor moves from the N_1 sector to the T_1 sector until labor productivity is equalized between the two sectors. This labor movement leads to a further increase in production in the T_1 sector and a decrease in production in the N_1 sector.

Due to this supply side effect, income in period one increases. This increase can be calculated:

$$(57) \quad \frac{\partial Y_1}{\partial A_{T_1}} = \left[Y_{T_1} + \frac{\partial L_{N_1}}{\partial A_{T_1}} \cdot \left(p_{N_1} \cdot A_{N_1} \cdot \gamma \cdot k_{N_1}^{1-\gamma} - A_{T_1} \cdot \beta \cdot k_{T_1}^{1-\beta} \right) \right] > 0$$

This higher income induces households to increase consumption of the three goods in both periods. As the supply of N_1 decreases, and the demand for N_1 increases, there is a clear increase in p_{N_1} . From (49) we get:

$$(58) \quad \frac{dp_{N_1}}{dA_{T_1}} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot b_{17} - a_{15} \cdot b_{57}) > 0$$

So, the increase in productivity in the tradable sector in period one causes a real appreciation of the home currency in that period, i.e. a decrease in the real exchange rate.¹³ This real appreciation in period one causes - via increasing installation costs - a real depreciation of the home currency in period two, which can be seen from (59) and (24). The impact on the price for nontradables can be calculated:

$$(59) \quad \frac{dp_{N_2}}{dA_{T_1}} = -\frac{\gamma-\beta}{\beta} \cdot p_{N_2} \cdot \frac{\varphi_1}{1+\varphi_1 \cdot p_{N_1}} \cdot \frac{dp_{N_1}}{dA_{T_1}} < 0$$

This decrease in p_{N_2} due to increasing installation costs leads to a decrease in supply of N_2 - similar to the movement from A towards B in Figure 1.

¹² Balassa (1964) and Samuelson (1964) explain deviations in the real exchange rate from purchasing power parity by different growth rates of labor productivity in the tradeable and nontradeable sector. Hsieh (1982) presents an early empirical work with time series data.

¹³ Here it is assumed that the installation parameter is not immoderately high. When this is not the case, then it could be possible for the excess demand for the nontradeables in period one to become negative due to decreasing investment.

The effect of the A_{T_1} increase on investment and the current account can easily be determined. The increase in income and the decrease in p_{N_2} cause an increase in demand for N_2 . For equilibrium on the N_2 market it is necessary for the supply of N_2 to increase by the same amount. This is brought about by a decrease in investment - moving along the Rybczynski line m in Figure 1 from point B to the north east. This decrease in investment leads to a current account surplus in period one. Further, the increase in income in period one and the decrease in p_{N_2} imply that consumption optimizing households will save part of the increase income in period one. This increase in saving leads to a further current account surplus in period one. So, from both the investment and the saving sides, the A_{T_1} increase leads to a current account surplus in period one. Due to the international budget constraint this implies a current account deficit in period two. The whole story can also be told differently; the productivity increase in the tradable sector in period one leads - due to intertemporal smoothing of consumption - to lower investments as well as to higher savings in period one and this necessarily induces a current account surplus in that period.

2. Increase in total factor productivity in the tradable sector in period two: $dA_{T_2} > 0$

It follows from (24) that - for a given p_{N_1} - an increase in A_{T_2} leads to an increase in p_{N_2} . This direct supply side effect can also be seen from the conditions (22) and (23) together with (25). (22) shows that, for a given real world interest rate and a given p_{N_1} an increase in A_{T_2} makes it profitable to produce with higher capital intensities, i.e. k_{T_2} increases and, because of (25) k_{N_2} increases in proportion to k_{T_2} . This increase in the optimal capital intensities can - with given investment - only be brought about by a decrease in the production of the capital intensive good T_2 , and a concomitant increase in the production of the labor intensive good N_2 . As a consequence of the factor reallocation, there are the following changes in the production plan:

$$(60) \quad \frac{\partial Y_{N_2}}{\partial A_{T_2}} = Y_{N_2} \cdot \left[\frac{L_{x_2}}{L_{N_2}} \cdot \frac{\gamma \cdot (1-\beta)}{\beta \cdot (\gamma-\beta)} + \frac{1-\gamma}{\gamma-\beta} + \frac{1-\gamma}{\beta} \right] > 0$$

and

$$(61) \quad \frac{\partial Y_{T_2}}{\partial A_{T_2}} = Y_{T_2} \cdot \left[-\frac{L_2}{L_{T_2}} \cdot \frac{1-\gamma}{\gamma-\beta} \right] < 0$$

Figure 4 shows this supply side effect. Due to the A_{T_2} increase, the transformation curve shifts away from the origin. The new optimal production point, B , on the new transformation curve has to be to the north west of the former point, A .¹⁴

¹⁴ Notice that, in the usual text book two goods two factor model with flexible factor prices the increase in A_{T_2} would lead - at constant product prices - to a new optimal production point to the south east of A , such as Z

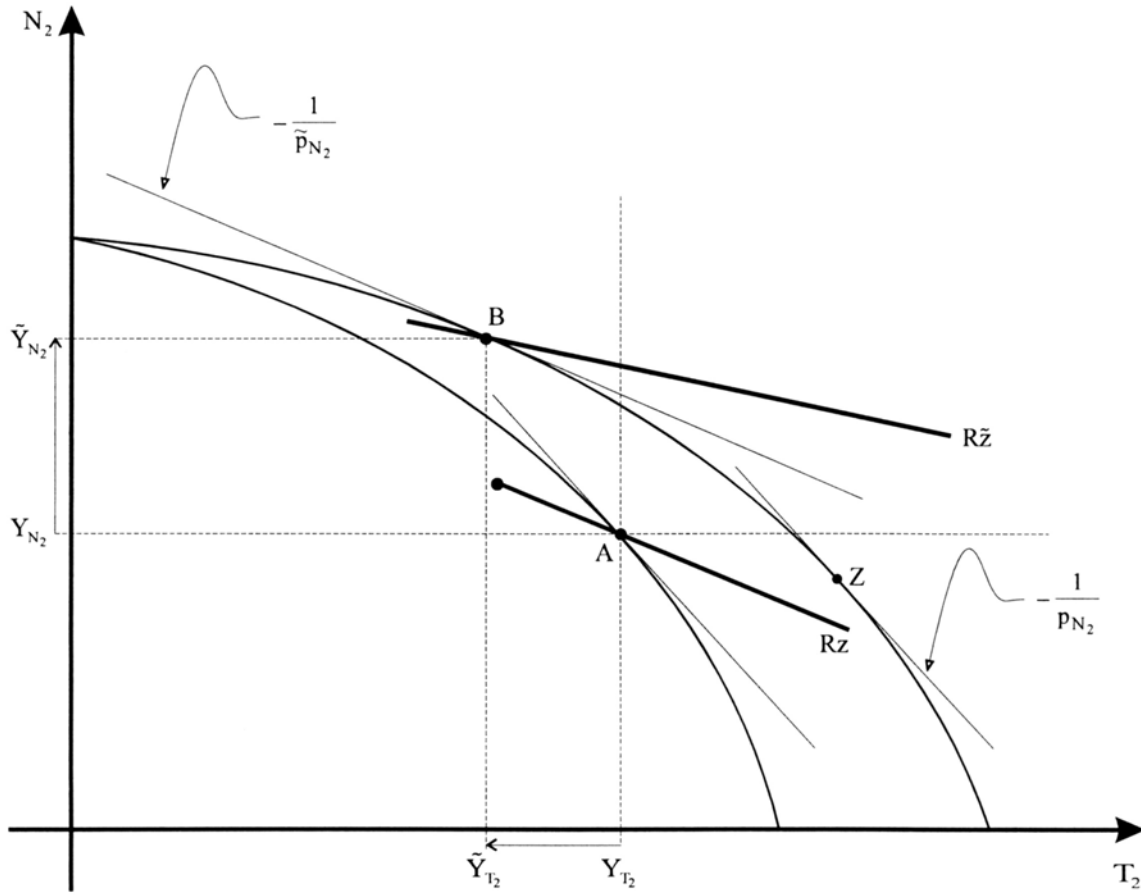


Figure 4

However, this is not the whole supply side story. As well as the direct supply side effect there is also an indirect supply side effect via p_{N_1} , as can be seen from (24). The increase in income in period two due to the A_{T_2} increase leads to an increase in consumption of all goods in all periods. The increase in demand for N_1 causes an increase in p_{N_1} . From (49) we get:

$$(62) \quad \frac{dp_{N_1}}{dA_{T_2}} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot b_{19} - a_{15} \cdot b_{59}) > 0$$

This increase in p_{N_1} increases installation costs of capital and makes it therefore necessary to produce less capital intensively. The optimal production point in Figure 4 moves to the south east of B on the transformation curve and p_{N_2} decreases. Considering both the direct and indirect supply side effects of the A_{T_2} increase, it is not clear a priori what will happen to p_{N_2} .

The final reaction of p_{N_2} can be calculated from (24) with (62):

$$(63) \quad \frac{dp_{N_2}}{dA_{T_2}} = p_{N_2} \cdot \left[\frac{\gamma}{\beta} - \frac{\gamma - \beta}{\beta} \cdot \frac{\varphi_1}{1 + \varphi_1 \cdot p_{N_1}} \cdot \frac{dp_{N_1}}{dA_{T_2}} \right] \begin{matrix} > \\ = \\ < \end{matrix} 0$$

(63) shows that the larger ϕ_1 , the capital installation costs, the more likely it is that p_{N_2} will decrease eventually.

Given this uncertain impact of the A_{T_2} increase on p_{N_2} , the impact on investment and the current account are also uncertain. From the consumption side, the current account in period one clearly deteriorates, because the increase in income in period two leads to an increase in consumption of M_1 and T_1 and therefore to more imports and fewer exports. From the investment side, the answer is not so clear. With no installation costs the supply increase of N_2 via direct supply side effect would exceed the demand increase via wealth effects, because the latter is distributed over all three products in both periods. Therefore, for equilibrium in the N_2 market, the supply has to be adjusted to the lower demand. This is brought about by an increase in investment – a movement to the right of B on the Rz line in Figure 4 – which leads to a further deterioration of the current account in period one.

However, if we consider capital installation costs and the indirect supply side effect, then point B in Figure 4 moves to the right on the transformation curve and it is possible that the supply increase of N_2 will be smaller than the demand increase of N_2 . In this case, a decrease in investment is necessary for equilibrium in the N_2 market. The decrease in investment improves the current account in period one. If this improvement exceeds the deterioration caused by the consumption side, the current account in period one will improve. (64) shows the uncertain impact of the A_{T_2} increase on investment in period one:

$$(64) \quad \frac{dK_2}{dA_{T_2}} = \frac{1+r_T}{-|A|} \cdot (a_{11} \cdot b_{59} - a_{51} \cdot b_{19}) \stackrel{>}{<} 0$$

If the second term in the brackets exceeds the first term, there will be a decrease in investment caused by the A_{T_2} increase. This is the more likely the larger a_{51} and b_{19} .

Assuming that the installation costs effect is sufficiently small – which is probably not an unrealistic assumption – so that (64) is positive, then the whole story can again be told differently: the expected increase in income due to the A_{T_2} increase leads via intertemporal consumption smoothing to dissaving in period one, and combined with the supply side effect, to an increase in investment. Therefore the current account in period one has to deteriorate.

3. Permanent increase in total factor productivity in the tradable sector:

$$dA_{T_1} = dA_{T_2} \equiv dA_T > 0$$

The effects on the real exchange rate and on the current account are obtained by adding the effects derived in parts 1 and 2. For the change in the real exchange rate in the first period we get:

$$(65) \quad \frac{dp_{N_1}}{dA_T} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot [b_{17} + b_{19}] - a_{15} [b_{57} + b_{59}]) > 0$$

(65) shows that the real appreciation of the home currency is now larger than in the case of a I one period increase in A_{T_1} . The reason is that a permanent increase in total factor productivity creates a stronger positive wealth effect which results in a higher excess demand for the nontradables in the first period. For the impact on the real exchange rate in period two, we get an expression similar to (63). However, the stronger increase in the nontradables' price in period one makes it more likely that the sign of the multiplier is negative. Regardless whether technical progress is permanent or temporary, the direct supply side effect requires the same increase in p_{N_2} . However, the larger wealth effect due to the permanent technical progress leads to much higher installation costs per unit of new invested capital - i.e. to a much higher indirect supply side effect - than in the case of an only temporary productivity shift. A sufficient condition to guarantee a permanent real appreciation is an elasticity of p_{N_1} with respect to the technical progress which is less than $(\gamma/\gamma - \beta)$.

Table 1

		current account		real exchange rate	
		period 1	period 2	period 1	period 2
increase of A_{T_t} in	period 1	improvement	deterioration	appreciation	depreciation
	period 2	deterioration	improvement	appreciation	appreciation

As the impact on the current account of an increase in A_{T_1} only and in increase in A_{T_2} only have opposite signs - as summarized in table 1 - the impact of a permanent increase on the current account is undetermined.¹⁵

However, it is reasonable to assume that in this case no large current account imbalances will occur. But, due to the asymmetric supply side reaction to increases in A_{T_1} and A_{T_2} , temporal current account imbalances cannot be excluded a priori.

Table one shows that the current account transmits part of the productivity shock induced wealth increase from one period to the other. The real exchange rate, on the other hand, is determined by the scarcity of nontradables at home and abroad. From this point of view, there is no causal economic relation between the real exchange rate and the current account; they are determined simultaneously by underlying real factors.

4. Increase in total factor productivity in the non tradable sector

As the various transmission mechanisms are identical to those caused by a productivity increase in the tradable sector, it is not necessary to recapitulate extensive economic explanations. Intuitively it is clear that a productivity increase in the non tradable sector should cause an increase in the real exchange rate, i.e. a real depreciation of the home currency.

¹⁵ It is assumed that the mstallation costs effect is sufficiently small so that an A-p increase worsens the current account in period one.

Take first an increase in factor productivity in the nontradable sector in period one; $dA_{N_1} > 0$. In this case, the home currency depreciates in period one because the supply side effect is greater than the demand increase for N , due to the wealth effect

From (49) we get:

$$(66) \quad \frac{dp_{N_1}}{dA_{N_1}} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot b_{16} - a_{15} \cdot b_{56}) < 0$$

Further because of lower installation costs, there is a real appreciation of the home currency in period two, i.e. p_{N_2} increases. This price increase leads to an excess supply on the market for N_2 . Therefore in the new equilibrium the investments in period one will be higher.

However, the economy will not realize a current account surplus, although the increase in total factor productivity occurs only in the first period. The reason for this is the following: with an unchanged price for the nontradables in period one, the technical progress leads to a higher output of N_1 , and a lower output of T_1 . The additional income of period one can only be transferred to the next period in the form of the tradable good. To meet this requirement, the price of the nontradables has to decrease in period one and to increase in period two. This decrease in p_{N_1} , and increase in p^{\wedge} lowers the consumer real interest rate and reduces in this respect the incentive to save. In addition, the optimal capital stock for period two increases, so that the economy ends up with a current account deficit in the first period.

The case of a productivity increase in the nontradable sector in the second period, $dA_{N_2} > 0$ is interesting. From (24) we get as the direct supply side effect:

$$(67) \quad \frac{dp_{N_2}}{p_{N_2}} : \frac{dA_{N_2}}{A_{N_2}} = -1$$

i.e. a future increase in productivity in the nontradable sector leads to a proportional real depreciation of the home currency at a given p_{N_1} . (22), (23) and (25) show that this result is compelling because with a constant real world interest rate the capital intensities k_{T_2} and k_{N_2} have to remain constant. Constant capital intensities, on the other hand, imply that an A_{N_2} increase leads to a proportionate increase in Y_{N_2} and to no change in Y_{T_2} . This can be seen easily after rewriting the production functions (13) and (14):

$$(13a) \quad Y_{N_2} = A_{N_2} \cdot L_{N_2} \cdot k_{N_2}^{1-\gamma}$$

$$(14a) \quad Y_{T_2} = A_{T_2} \cdot L_{T_2} \cdot k_{T_2}^{1-\beta}$$

Differentiating (13a) and (14a) with respect to A_{N_2} yields:

$$(68) \quad \frac{dY_{N_2}}{Y_{N_2}} = \frac{dA_{N_2}}{A_{N_2}}$$

and

$$(69) \quad dY_{T_2} = 0$$

From (67), (68) and (69) it follows that there is no wealth effect from the A_{N_2} increase. As we further assumed - when modelling household demand - that the consumer goods are net substitutes, i.e. the price decrease of N_2 has no direct spillover effects to the demand in the other markets, there is no further adjustment in the economy; we get $dY_2 = dCA_1 = dCA_2 = 0$, and, of course $dp_{N_1} = 0$. This case is shown in Figure 5. The new production point, B, is on the vertical $Y_{T_2}AB$ above the old production point, A, that is, the A_{N_2} increase leaves production of the tradeables unchanged.

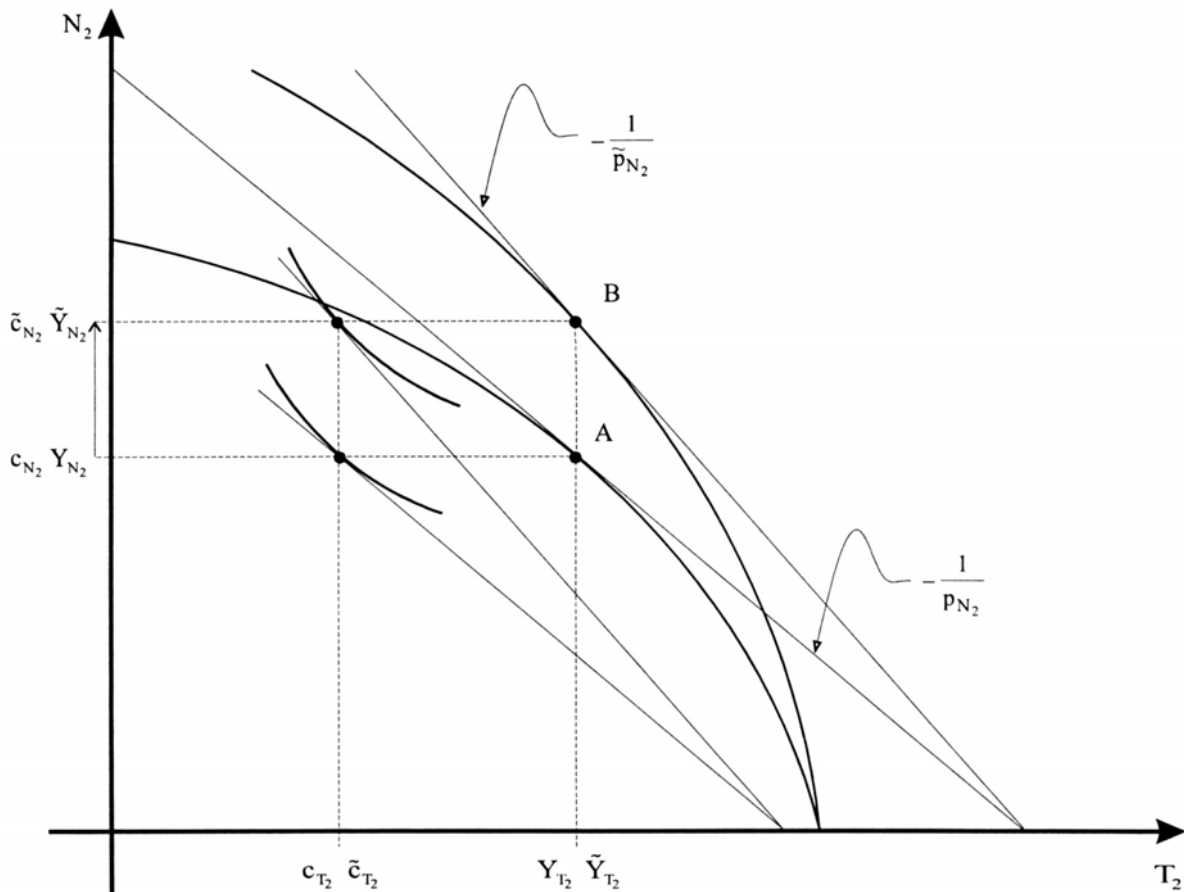


Figure 5

Next, a permanent increase in the factor productivity in the nontradable sector will be investigated: $dA_{N_1} = dA_{N_2} > 0$. In this case, the direct impact is a real depreciation of the home currency in both periods. Notice that the depreciation in period one is identical with the depreciation when A_{N_1} increases separately, because there is no additional impact from the A_{N_2} increase on p_{N_1} . For the real exchange rate in the second period we get a new and

ambiguous result: while the lower installation costs increase the price of the nontradables and the real exchange rate in period two, the technical progress in N_2 sector lowers these variables. If the installation of one unit of newly invested capital does not require too many nontradables, then the direct productivity effect on the real exchange rate will dominate and we get a permanent real depreciation. The absence of a wealth effect due to the variation in A_{N_2} also implies that the impact on investment and the current account of a permanent increase in total factor productivity in the nontradable sector is the same as in the case of an A_{N_1} increase.

5. Increase in labor supply: $dL_t > 0$

One reason for an increase in the labor supply is immigration of labor from abroad. This has been an issue in Western Europe since the breakdown of communism in Eastern Europe. There is a lot of labor migration from Eastern to Western Europe. This labor migration has several economic and social aspects. In our model some of these aspects can be investigated. It can be shown how labor immigration and, thus an increase in the labor supply, affects the real exchange rate and the current account.

First it will be assumed that the labor supply increases only in period one, i.e. $dL_t > 0$ and $dL_2 = 0$. This is the case if immigrants work for one period and then retire. With given product prices the increase in L , leads to an increase in the supply of both products in period one. However, the increase in the labor intensive nontradables is relatively larger than in the capital intensive tradeables:

$$(70) \quad \left. \frac{dY_{N_1}}{Y_{N_1}} : \frac{dY_{T_1}}{Y_{T_1}} \right|_{dL_1} = \frac{\gamma \cdot (1 - \beta)}{\beta \cdot (1 - \gamma)} > 1$$

The increase in L_1 produces a positive wealth effect, as income in the first period increases. This increases the demand for all three goods in both periods. As the supply of N_1 and the demand for N_1 both increase, the way the real exchange rate in the first period will be affected is uncertain. From (49) we get:

$$(71) \quad \frac{dp_{N_1}}{dL_1} = \frac{1 + r_T}{-|A|} \cdot (a_{55} \cdot b_{11} - a_{15} \cdot b_{51}) \begin{matrix} > \\ = 0 \\ < \end{matrix}$$

A sufficient condition for (71) to be negative is a positive b_{11} . Because of the disproportional increase in supply in favor of the nontradables and the fact that additional income is used for increasing demand for all six goods, a positive sign of b_{11} will be the practically relevant case. The decrease of p_{N_1} causes an increase in p_{N_2} via lower installation costs. These opposite reactions of the consumer prices in the two periods decrease consumer real interest rate.

From the aspect of intertemporal consumption smoothing, we would expect a current account deficit in the second period and a surplus in the first one. However, the decrease in consumer real interest rate causes fewer savings in period one. Further, we do not know how

investment reacts: the wealth effect leads to an increasing demand for N_2 , while the increasing price of N_2 - due to decreasing installation costs - stimulates an excess supply. Therefore, the direction of the change in the optimal capital stock and the development of the current account is an open question.

If the labor supply increases in the second period, the transformation curve will shift away from the origin and the production point will move, with given p_{N_2} , on a classical Rybczynski line to the north west. The positive wealth effect leads to an appreciation of the home currency in the first period because the demand for N_1 increases. From (49) we get:

$$(72) \frac{dp_{N_1}}{dL_2} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot b_{12} - a_{15} \cdot b_{52}) > 0$$

As p_{N_2} is affected by the L_2 increase via higher costs for installing capital goods, the real exchange rate of the second period depreciates. An increase in p_{N_1} combined with a decrease in p_{N_2} implies a higher consumer real interest rate and thus higher savings.

There are two effects in the market for N_3 : on the one hand, the increase in labor endowment leads to an increase in supply of the nontradables which will be dampened, compensated or even overcompensated by the increase in installation costs. On the other hand, the wealth effect and the decreasing relative price lead to an increasing demand. However, with a sufficiently small installation parameter (pp the increase in L^{\wedge} will lead to an excess supply of N_2 and the firm increases investments in order to meet the consumption demand. In this case, it is very likely that the consumption smoothing effect and the investment effect lead to a current account deficit in period one despite the increase in consumer real interest rate.

If we have a permanent labor supply increase, i.e. $dL_1 = dL_2 > 0$, then both the impact on the real exchange rate in each period and the impact on the current account will be uncertain because the increases in L , and L^{\wedge} will produce opposite effects.

6. Change in the real world interest rate: $dr_T > 0$

For a small country the world interest rate is given. The exogenous increase in r_T has a negative wealth effect because of a smaller present value of the second period income and the changing production plan which is associated with a lower price of the nontradables in period two. Therefore, the demand for N_1 decreases and this leads to a real depreciation of the home currency in the first period. From (49) we get:

$$(73) \frac{dp_{N_1}}{dr_T} = \frac{1+r_T}{-|A|} \cdot (a_{55} \cdot b_{13} - a_{15} \cdot b_{53}) < 0$$

Considering (73), the eventual effect of the increase in r_T , on the price of nontradables in period two can be calculated:

$$(73) \frac{dp_{N_2}}{dr_T} = -\frac{1-\beta}{\beta} \cdot p_{N_2} \cdot \left[\frac{1}{1+r_T} + \frac{\varphi_1}{1+\varphi_1 \cdot p_{N_1}} \cdot \frac{dp_{N_1}}{dr_T} \right] \begin{matrix} > \\ = \\ < \end{matrix} 0$$

Here we have two opposite effects: an r - r increase leads via the direct supply effect to a lower optimal capital intensity which requires a shift in the output structure in favor of the tradable; this is associated with a lower p_{N_2} . Due to the real depreciation in period one, the increase in the capital costs - caused by the higher real interest rate - is dampened or - if φ_1 matters a lot - compensated, or even overcompensated.

The impact on investment and the current account is undetermined. If the r_T increase causes a reduction in the supply of N_2 larger than the reduction in the demand for N_2 due to the negative wealth effect, then a decrease in investment is necessary for equilibrium in the N_2 market. In this case there will be a current account surplus in period one, because, due to the negative wealth effect, consumption demand also decrease in period one.

7. Terms of Trade effects

For the initial equilibrium we assumed no surplus or deficit in the current account. Because in Households' optima in every period all three goods are consumed, the home country imported the M -good and exported the T -good. Thus the terms of trade are the reciprocal of the price of imports, p_{M_t} .

Due to our assumptions that the consumption goods are net substitutes, i.e. the cross price elasticities are zero, changes in the price of imports have no impact on the import value. Further, according to our definition of national wealth, we neglect wealth effects associated with terms of trade changes.¹⁶ Therefore, terms of trade changes cause no spillovers to the other markets. This is the reason why there is only the direct effect from changes in the terms of trade to the real exchange rate and no additional indirect effects due to changing prices of nontradables. The only impact is on the consumer real interest rate: if p_{M_t} increases in period one (two) there will be an increase (a decrease) in r_C . Because of the real appreciation in period one (two) the depreciation rate from period one to period two increases (decreases). Together with the increase in r_C the real interest rate parity in (9) is met. The decrease in m_1 (m_2) changes C_1 (C_2) to the amount necessary to meet the optimality condition (34). If there is a permanent increase in p_{M_t} then there will be no impact on r_C .

These rigorous results derive from two crucial assumptions: on the one hand, the utility function has a very simple specification and, on the other hand, the import good is only used for consumption and not for production. So, M_t cannot be interpreted as imported raw materials.

¹⁶ National wealth, which is the present value of national income of the two periods is determined entirely by the supply side, see equation (16).

IV. Summary and conclusion

The paper supports the common view that the impact of supply side shocks on the real exchange rate mainly depends on which sector of the economy is hit most by the shock whereas the impact on the current account mainly depends on the period in which the shock takes place. When investment installation costs are neglected, then - at a given world interest rate - the expected real exchange rate of a small open economy is determined only by expected supply side factors. The consideration of investment installation costs implies that current demand side factors have an impact on the expected real exchange rate via their impact on the current real exchange rate. Increasing installation costs or a current appreciation cause a future depreciation of the home currency. The existence of installation costs makes the impact of supply side shocks on the expected real exchange rate, and especially on the expected current account, less clear.¹⁷

The main result of this paper is that in an intertemporal general equilibrium approach there is no causal relationship between the real exchange rate and the current account. They are both determined simultaneously by the underlying real factors. This result suggests the following for an efficient national and international monetary system, in evolutionary free market economies positive supply side shocks of various kinds, especially technical progress, will and ought to take place to the advantage of the consumer. Unless these supply side shocks are identical in the various countries, they will induce real exchange rate changes in order to assure optimal production and consumption. These necessary changes are the larger, the larger are the supply side shocks. (3a) shows that there are two extreme alternatives for how real exchange rate changes can take place in monetary economic: with the constant world prices either the nominal prices of the domestic consumer goods basket, \tilde{P}_{C_t} or the nominal exchange rate S_t , changes this task. If, on the one hand, the governments have implemented for a fixed exchange rate system, then the necessary real exchange rate change has to be brought about by a change in the domestic nominal price level. If, on the other hand, the monetary authority wants to achieve domestic price level stability, then the nominal exchange rate has to be flexible in order to produce the real exchange rate changes for production and consumption optimality. From this point of view there are convincing arguments for flexible nominal exchange rates if domestic price level stability is a serious economic target and if the economy experiences various supply side shocks which are not identical to those in the rest of the world.¹⁸ However, it also has to be emphasized that - from this point of view - the necessity for flexible nominal exchange rates diminishes with increasing openness of the economy. The larger is the tradable sector compared to the nontradable one, the smaller are the real exchange rate changes caused by a given supply side shock. In a completely open economy, i.e. there are no longer nontradables, the monetary authority has no difficulty in accommodating supply side shocks and holding the domestic price level constant at fixed exchange rates. However, in such a world, there might still be another serious argument in favor of flexible exchange rates: to protect the economy from foreign monetary shocks.

¹⁷ For an overview see table 2 in the appendix.

¹⁸ In order to get precise results concerning the impact of various supply side shocks on \tilde{P}_{C_t} it is necessary to incorporate a monetary sector in the present model because real shocks do have an impact on the real money demand.

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Appendix

$$A = \begin{bmatrix} \frac{\partial c_{N_1}}{\partial p_{N_1}} - \frac{\partial Y_{N_1}}{\partial p_{N_1}} & 0 & 0 & 0 & \frac{\partial c_{N_1}}{\partial K_2} + \varphi_1 \\ \frac{\partial c_{M_1}}{\partial p_{N_1}} & -1 & 0 & 0 & \frac{\partial c_{M_1}}{\partial K_2} \\ \frac{\partial c_{M_2}}{\partial p_{N_1}} & 0 & -1 & 0 & \frac{\partial c_{M_2}}{\partial K_2} \\ \frac{\partial c_{T_2}}{\partial p_{N_1}} - \frac{\partial Y_{T_2}}{\partial p_{N_1}} & (1+r_T) \cdot p_{M_1} & p_{M_2} & -(1+r_T) & \frac{\partial c_{T_2}}{\partial K_2} - \frac{\partial Y_{T_2}}{\partial K_2} \\ \frac{\partial c_{N_2}}{\partial p_{N_1}} - \frac{\partial Y_{N_2}}{\partial p_{N_1}} & 0 & 0 & 0 & \frac{\partial c_{N_2}}{\partial K_2} - \frac{\partial Y_{N_2}}{\partial K_2} \end{bmatrix}$$

$$|A| = -(1+r_T) \cdot [a_{11} \cdot a_{55} - a_{51} \cdot a_{15}] > 0$$

$$B = \begin{bmatrix} \frac{\partial Y_{N_1}}{\partial L_1} - \frac{\partial c_{N_1}}{\partial L_1} & -\frac{\partial c_{N_1}}{\partial L_2} & -\frac{\partial c_{N_1}}{\partial r_T} & 0 & 0 & \frac{\partial Y_{N_1}}{\partial A_{N_1}} - \frac{\partial c_{N_1}}{\partial A_{N_1}} & \frac{\partial Y_{N_1}}{\partial A_{T_1}} - \frac{\partial c_{N_1}}{\partial A_{T_1}} & \frac{\partial c_{N_1}}{\partial A_{N_2}} & -\frac{\partial c_{N_1}}{\partial A_{T_2}} \\ -\frac{\partial c_{M_1}}{\partial L_1} & -\frac{\partial c_{M_1}}{\partial L_2} & -\frac{\partial c_{M_1}}{\partial r_T} & -\frac{\partial c_{M_1}}{\partial p_{M_1}} & 0 & -\frac{\partial c_{M_1}}{\partial A_{N_1}} & -\frac{\partial c_{M_1}}{\partial A_{T_1}} & -\frac{\partial c_{M_1}}{\partial A_{N_2}} & -\frac{\partial c_{M_1}}{\partial A_{T_2}} \\ -\frac{\partial c_{M_2}}{\partial L_1} & -\frac{\partial c_{M_2}}{\partial L_2} & -\frac{\partial c_{M_2}}{\partial r_T} & 0 & -\frac{\partial c_{M_2}}{\partial p_{M_2}} & -\frac{\partial c_{M_2}}{\partial A_{N_1}} & -\frac{\partial c_{M_2}}{\partial A_{T_1}} & -\frac{\partial c_{M_2}}{\partial A_{N_2}} & -\frac{\partial c_{M_2}}{\partial A_{T_2}} \\ -\frac{\partial c_{T_2}}{\partial L_1} & \frac{\partial Y_{T_2}}{\partial L_2} - \frac{\partial c_{T_2}}{\partial L_2} & \frac{\partial Y_{T_2}}{\partial r_T} - \frac{\partial c_{T_2}}{\partial r_T} & -(1+r_T)m_1 & -m_2 & -\frac{\partial c_{T_2}}{\partial A_{N_1}} & -\frac{\partial c_{T_2}}{\partial A_{T_1}} & \frac{\partial Y_{T_2}}{\partial A_{N_2}} - \frac{\partial c_{T_2}}{\partial A_{N_2}} & \frac{\partial Y_{T_2}}{\partial A_{T_2}} - \frac{\partial c_{T_2}}{\partial A_{T_2}} \\ -\frac{\partial c_{N_2}}{\partial L_1} & \frac{\partial Y_{N_2}}{\partial L_2} - \frac{\partial c_{N_2}}{\partial L_2} & \frac{\partial Y_{N_2}}{\partial r_T} - \frac{\partial c_{N_2}}{\partial r_T} & 0 & 0 & -\frac{\partial c_{N_2}}{\partial A_{N_1}} & -\frac{\partial c_{N_2}}{\partial A_{T_1}} & \frac{\partial Y_{N_2}}{\partial A_{N_2}} - \frac{\partial c_{N_2}}{\partial A_{N_2}} & \frac{\partial Y_{N_2}}{\partial A_{T_2}} - \frac{\partial c_{N_2}}{\partial A_{T_2}} \end{bmatrix}$$

Table 2

			real exchange rate		current account	
			period 1	period 2	period 1	period 2
increase of A_{T_t} in	period 1	$\varphi_1 = 0$	appreciation	0	improvement	deterioration
		$\varphi_1 > 0$	appreciation	depreciation	improvement	deterioration
	period 2	$\varphi_1 = 0$	appreciation	appreciation	deterioration	improvement
		$\varphi_1 > 0$	appreciation	?	?	?
increase of A_{N_t} in	period 1	$\varphi_1 = 0$	depreciation	0	0	0
		$\varphi_1 > 0$	depreciation	appreciation	deterioration	improvement
	period 2	$\varphi_1 = 0$	0	depreciation	0	0
		$\varphi_1 > 0$	0	depreciation	0	0
increase of L_t in	period 1	$\varphi_1 = 0$	depreciation	0	improvement	deterioration
		$\varphi_1 > 0$	depreciation	appreciation	?	?
	period 2	$\varphi_1 = 0$	appreciation	0	deterioration	improvement
		$\varphi_1 > 0$	appreciation	depreciation	?	?
increase of r		$\varphi_1 = 0$	depreciation	depreciation	?	?
		$\varphi_1 > 0$	depreciation	?	?	?
increase of p_{M_t} in	period 1	$\varphi_1 = 0$	appreciation	0	0	0
		$\varphi_1 > 0$	appreciation	0	0	0
	period 2	$\varphi_1 = 0$	0	appreciation	0	0
		$\varphi_1 > 0$	0	appreciation	0	0

$\varphi_1 = 0$: without installation costs

$\varphi_1 > 0$: with installation costs